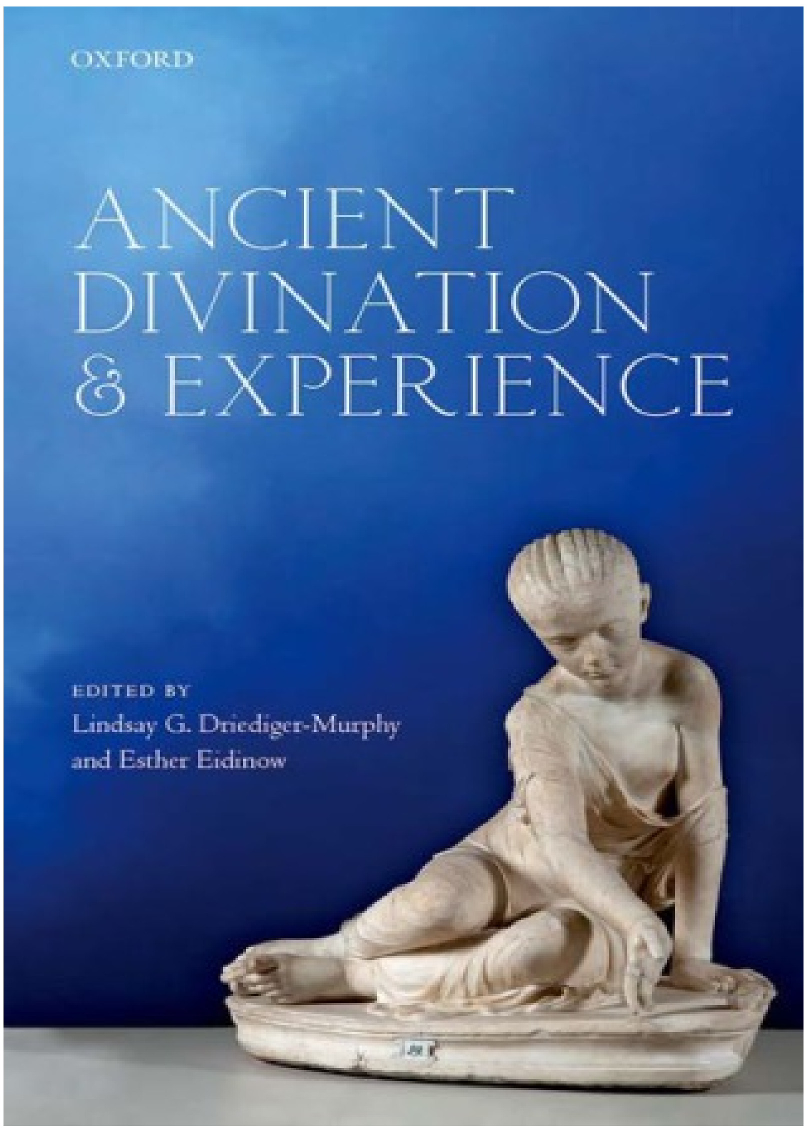
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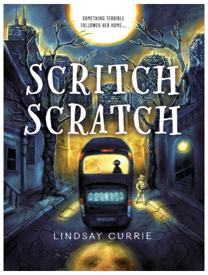


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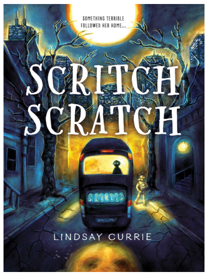


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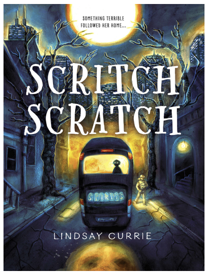


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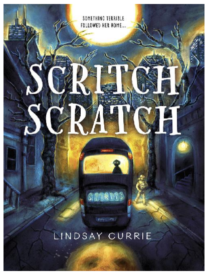


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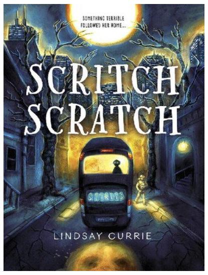

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# ANCIENT DIVINATION & EXPERIENCE

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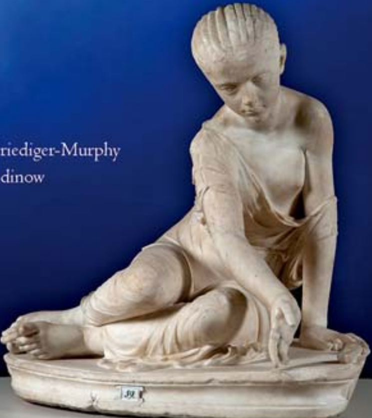

# Ancient Divination and Experience

# Ancient Divination and Experience

*Edited by*

LINDSAY G. DRIEDIGER-MURPHY
AND ESTHER EIDINOW

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# Contents

## PART III. DIVINE PRESENCE?

# List of Abbreviations

For ancient authors and works, and modern collections of ancient evidence, we have used the abbreviations in S. Hornblower, A. Spawforth, and E. Eidinow (eds.) 2012. *Oxford Classical Dictionary* (4th edn). Oxford. Additional abbreviations are listed below:

| | |
|---|---|
| *ABL* | Harper, R. F. and Waterman, L. 1892–1914. *Assyrian and Babylonian Letters Belonging to the Kouyunjik Collection of the British Museum*, 14 vols. Chicago. |
| *BBR* | Zimmern, H. 1901. *Beiträge zur Kenntnis der babylonischen Religion*. Leipzig. |
| Bu 89-4-26 | Tablets acquired by Wallace Budge and accessioned by the British Museum on 26 April 1889. |
| *CAD* | Oppenheim, A. L., Reiner, E. et al. (eds.) 1956–. *The Assyrian Dictionary of the Oriental Insitute of the University of Chicago*. Chicago. |
| Didyma | McCabe, D. F. 1985. *Didyma Inscriptions: Texts and List*. "The Princeton Project on the Inscriptions of Anatolia", The Institute for Advanced Study. Princeton. Includes: Rehm, A. 1958. *Didyma, II: Die Inschriften*. Berlin. |
| K | Tablets in the Kouyunjik collection of the British Museum. |
| *KAR* | Ebeling, E. 1919; 1920. *Keilschrifttexte aus Assur religiösen Inhalts,* I/II. Leipzig. |
| Ki 1904-10-9 | Tablets acquired by Leonard King and accessioned by the British Museum on 9 October, 1904. |
| [Luc.] *Amor.* | Ps. Lucian, *Amores* (*Affairs of the Heart*). |
| *RMA* | Thompson, R. C. 1900. *The Reports of the Magicians and Astrologers of Nineveh and Babylon*. London. |
| *SAA* | State Archives of Assyria. |
| *MSL* | Landesberger, B. et al. 1937–. *Materialien zum sumerischen Lexikon/ Materials for the Sumerian Lexicon*. Rome. |

A note on spelling: we have adopted Greek spelling for names of people and places, except in those cases where the Latinized form is more familiar, or where it could cause confusion with the abbreviated form.

# List of Contributors

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**Jason P. Davies** is interim director of the Arena Fellowship scheme in the University College London Centre for Advancing Research-based Education. He has taught extensively, and published parsimoniously, on ancient culture, religion and historiography, belief and secularism in the ancient world, interdisciplinarity, threshold concepts and history and reception of science, as part of a wide interest in people's interactions with knowledge systems. He is currently undertaking long-term ethnographic research on disciplinary and pedagogic cultures in universities and developing a monograph about Mary Douglas' Cultural Theory and higher education. With Esther Eidinow and Susan Deacy, he is a co-founder of the Teaching and Learning Ancient Religions network.

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**Esther Eidinow** is Professor of Ancient History at the University of Bristol, UK. Her research focuses on ancient Greek culture, especially religion and magic, and she is particularly interested in anthropological and cognitive approaches to these areas. She is the co-founder and co-editor in chief of the *Journal of Cognitive Historiography*. As well as numerous articles, her publications include *Oracles, Curses, and Risk among the Ancient Greeks* (2007), *Luck, Fate and Fortune: Antiquity and its Legacy* (2010), and *Envy, Poison and Death*: *Women on Trial in Classical Athens* (2016).

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scholar, musician, and artist'. To learn more about his projects or to download his publications, visit http://faculty.washington.edu/snoegel.

**Lisa Raphals** (瑞麗) studies the cultures of early China and Classical Greece, with interests in comparative philosophy, religion, and history of science. She is Professor of Chinese and Comparative Literature, University of California Riverside, cooperating faculty in the departments of Philosophy and Religious Studies, and serves on faculty of the Tri-Campus PhD program in Classics. She is the author of *Knowing Words: Wisdom and Cunning in the Classical Traditions of China and Greece* (Cornell, 1992), *Sharing the Light: Representations of Women and Virtue in Early China* (SUNY, 1998), and *Divination and Prediction in Early China and Ancient Greece* (Cambridge, 2013). Representative scholarly articles include: 'Skeptical Strategies in the Zhuangzi and Theaetetus' (*Philosophy East & West*, 1994), 'Debates about Fate in Early China' (*Études Chinoises*, 2014), 'Sunzi versus Xunzi: Two Views of Deception and Indirection' (*Early China*, 2016), and 'Body and Mind in Early China and Greece' (*Journal of Cognitive Historiography*, 2017).

**Federico Santangelo** is Senior Lecturer in Ancient History at Newcastle University. He has taught and published on various aspects of Roman history, mostly Republican, and is the author of *Sulla, the Elites and Empire. A Study of Roman Policies in Italy and the Greek East* (2007), *Divination, Prediction and the End of the Roman Republic* (2013), and *Marius* (2016). He has also edited several volumes, including (with J. H. Richardson) *Priests and State in the Roman World* (2011). He is Reviews Editor of *Histos*.

**Andrew Stiles** received a BA (Hons) and MPhil from the University of Sydney, and a DPhil from the University of Oxford. He is currently a Teaching Fellow in Ancient History at University College London. His doctoral research examines a series of crises (from the Triumviral period to the Flavian dynasty) in which conceptions of the future of Rome were articulated, and explores the hopes and fears generated by such projections and their influence on political developments. His broader research interests include the political, social, and religious history of the early Principate, and the history of ideas in the Roman world. He has published articles on Ovid and Germanicus, and the political significance of the cult of *Spes* in Augustan Rome.

# Introduction

*Lindsay G. Driediger-Murphy and Esther Eidinow*

## 1. 'You Believe; We Know'

This volume is the result of a conference held in London, in July 2015, on the topic of divination in ancient cultures, with particular focus on Greece and Rome.[1] The conference itself arose from the desire to explore approaches that diverged from the prevailing scholarly functionalist analyses of ancient divination. A recent summary of the state of anthropological research in this area will come as no surprise to classicists: 'regardless of whether divination is conceived of as a means for providing emotional reassurance, a tool for restoring and sustaining a social structure, an instrument for making decisions, building consensus, and establishing political legitimacy, or an aid for maintaining a cognitive order', the assumption in most studies has been that 'divination [is] a derivation from, and representation of, some underlying processes which it serves to control'.[2]

In scholarship on the ancient world, there is no doubt that such explanations reveal important socio-political dimensions of divinatory practice, but they also run the risk of obscuring from view the very people, ideologies, and experiences that scholars seek to understand. The problems raised by this approach have recently been summarized by the religious studies and anthropology scholar Patrick Curry: it 'allows the observer-theorist to distance him- or herself from the subject matter and its human subjects, and then to inform them what they are "really" doing. You believe; we know.'[3] In contrast, the papers at this conference sought to re-examine what ancient

[1] The editors would like to thank the Institute of Classical Studies for their generous sponsorship of the conference, and the following for their support of this project: Simon Hornblower, Charlotte Loveridge, Georgina Leighton, the production team at OUP, and the contributing authors of this volume. This project (research and volume) was supported by the AHRC, the Leverhulme Trust, and the Social Sciences and Humanities Research Council of Canada.

[2] Myhre 2006. [3] Curry 2010: 4.

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people—primarily those in ancient Greek and Roman communities, but also Mesopotamian and Chinese cultures—thought they were doing through divination, and what this could tell us about the religions and cultures in which divination was practised. Contributors to the 2015 conference were asked to engage with one or more of a set of shared questions:

- What kinds of gods do ancient forms of divination presuppose?
- What beliefs, anxieties, and hopes did divination seek to address?
- What were the limits of human 'control' of divination?
- What kinds of human–divine relationships did divination create/sustain?

## 2. Beyond Functionalism

Previous scholarship on divinatory practices of course comprises many, differentiated fields: the approaches taken by the two disciplines of Greek and Roman history, just as an example, have been intriguingly dissimilar. In research on ancient Greek divination or *mantikē*, scholars, moving beyond the earlier, more descriptive or documentary approaches to ancient divination, have drawn on the resources of anthropology to explore the ways in which a practice that at first sight seems to make little sense, can be viewed as quite 'rational' within the cognitive constraints of its own culture.[4] Although the binary categories of rationality/irrationality are no longer deemed relevant in these discussions,[5] scholars have, in general pursued a functionalist line of analysis, seeking the socio-political implications of divination.[6] Thus, it has

[4] Ethnologists and anthropologists of the nineteenth and early twentieth centuries led the way in providing detailed descriptions of divinatory practices and experiences in many cultures. When interpreting this data, however, those studies tended to explain divination's influence and the experiences it generated as the result of 'primitive' or 'pre-scientific' worldviews (e.g. Tylor 1871; Frazer 1906–15 [1890]; Lévy-Bruhl 1951 [1910]). Such interpretations have long since been discarded. Descriptive approaches: some examples include Roux 1946; Amandry 1950; Parke 1939, 1967a, 1967b, 1985; Parke and Wormell 1956; Günther 1971; Fontenrose 1978. Rationality: Vernant 1974: 18–19 represents the oracle as a form of rationality that is confronted by the rationality of Greek political structure; cf. Burkert 2005: esp. 30 on rationality vs. irrationality.

[5] Cf. the more schematic overview of current scholarship in Struck 2016.

[6] A famous exception to this is Vernant et al. 1974; this is mentioned in Johnston and Struck 2005. Johnston, in the introduction to that volume, raises the way that 'divination also helps us to understand the mentalities that organize other essential aspects of human existence' (p. 11). Most recently, Trampedach (2015) has examined divination as a 'Kommunikationsphänomen' (p. 14), and explored its role not only in various political structures and in the development of political rationality (p. 564), but also in the relationship that this communicative phenomenon instantiated between men and gods.

generally been agreed that communities consulted oracles because they sought to resolve their internal differences via an unbiased authority, usually located outside the city.[7] Divination provided a mode of achieving consensus, and, as such it 'also serves for the scholar, as an indication of where legitimation is most necessary'.[8] In turn, scholars have argued that individuals sought and found in divination a heightened sense of personal control.[9] In contrast, although studies of Roman divination have typically engaged less explicitly with the anthropological literature, they too have tended to focus on the social and political functions served by divination. The various forms of public divination at Rome (augury, state-sanctioned haruspicy, and prodigy-interpretation) have attracted particular attention. Such forms of divination are said to have enhanced magisterial, senatorial, or imperial authority; to have calmed panic and validated decisions taken by officials and senate; to have enforced magisterial submission to the senate and priestly bodies (particularly in the Republic); to have strengthened claims to political legitimacy (a phenomenon especially well documented in the Imperial period); to have helped Romans to cope with situations of uncertainty and helplessness; and to have created delay in order to buy 'breathing-space' for calmer and more reasoned discussion and/or the application of 'peer-pressure'.[10] Forms of public divination have also tended to be seen above all as a tool of the elite, employed by the political authorities to bolster their power over the lower orders, by the senate majority to compel individual politicians' adherence to an emerging consensus, by the individual

[7] For example, Morgan 1990: esp. 184–5; Parker 2000; Rosenberger 2001 emphasizes cultural behaviours and techniques.

[8] Johnston 2005: 23.

[9] Rüpke following Turner (2005b (vol. 3): 1443); Burkert 2005: 30.

[10] A few examples: Vernant 1974: 10 (divination makes decision-making appear more 'objective'); Liebeschuetz 1979: 8ff.; Wardman 1982: 20, 45; Scheid 1985: 46 (augury legitimated public decisions); Gordon 1990: 192–3 (religion as a 'veil' concealing the 'real-world forces' [i.e. actions of the elite] that truly shaped events); North 1990: 64–5 (divination could validate public decisions, though note his criticisms of Liebeschuetz's emphasis on this); Dowden 1992: 35; Orlin 1997: 90–1 (consultations of the Sibylline Books calmed panic and validated senate decisions, though he recognizes that concern about the gods could also play a role); Rosenberger 1998; Rüpke 2005a (divination bought time for the negotiation of elite consensus); Rüpke 2005b: 1443–4 (divination as psychological aid, social process, and symbol), 1450 (divination as 'Widerspruchsschleifen, die insgesamt den Entscheidungsprozeß in Richtung Konsens optimieren'); Rüpke 2012: 479: divination is 'une forme de comportement collectif qui, en situation d'incertitude, à l'aide de roles sociaux définis pour l'interprétation et l'élaboration rituelle de signes standardisés, recherche et articule l'accord et le désaccord.' Note that the applicability to Rome of the 'control of helplessness' theory prominent in studies of Greek divination is questioned by North 1990: 62–4.

magistrate to alter the behaviour of his rivals and opponents, or by the individual claimant to power to bolster his own case.

Our intention is not to dismiss these insights, but to highlight other aspects of ancient divination which such functionalist approaches have tended to overlook. Recent developments in Classics, anthropology, and cognitive science encourage progress in several new aspects of exploration. In the discipline of anthropology, several scholars have offered productive critiques of an excessive reliance on functionalist interpretations of divination,[11] criticism with which Classics has not yet fully engaged. In the discipline of cognitive science, studies of brain activity during perceived religious experiences suggest that these can be understood without assuming manipulation, hypocrisy, or deception on the subject's part. Research into ancient Greek and Roman divination is also exploring more and different dimensions than before. For example, scholars of ancient Greek divinatory practices have begun to examine divinatory activities, or discourse concerned with these activities, as ways for human beings to express particular aspects of their relationship and interactions with their environment—an environment that, of course, included the divine.[12] On the Roman side, there is a growing recognition, drawing on critiques of the *polis*-religion model,[13] that even public religion was not simply the preserve of the elite. For divination to fulfil the functions we typically ascribe to it, it must have dealt in symbols, concerns, and ideas which resonated both with those in power and those (of lower social status) whose support kept them there.[14] There has also been a burst of interest in the diversity of religious experiences and actors in both Greek and Roman contexts: in the religion of families and individuals, in the kinds of emotions produced by religion, and in beliefs and activities which our elite sources may depict as 'fringe' or 'deviant', but which may have played a larger role in the life of the ancients than this characterization suggests (and we have recognized).[15] The essays in this volume engage with these advances to identify and elucidate previously

[11] See especially the papers collected in Curry 2010. For an example of how a comparative anthropological approach may be used to consider features of divination across several ancient Mediterranean cultures, see Beerden 2013, with Harrison 2015a and Eidinow 2015.

[12] Eidinow 2007 examines both divination and binding spells as ways of expressing and responding to culturally constructed conceptions of risk; Struck 2016 analyses philosophical texts on divination as reflections on intuitive knowledge; on oracular narratives, see Dougherty 1992, Maurizio 1997, and Kindt 2016.

[13] E.g. Bendlin 1997; Woolf 1997; Bendlin 2000; Kindt 2012.

[14] Ripat 2006.

[15] Parker 2011: 224–64; Chaniotis 2012; Chaniotis and Ducrey 2013; Rüpke 2013; Scheid 2013 (English edition 2016); Santangelo 2013; Whitmarsh 2015.

understudied aspects of ancient divinatory experience and practice. Special attention is paid to the experiences of non-elites, the theological content of divination, the ways in which divinatory techniques could surprise their users by yielding unexpected or unwanted results, the difficulties of interpretation with which divinatory experts were thought to contend, and the possibility that divination could not just ease, but also exacerbate, anxiety in practitioners and consultants. By analysing these aspects, we suggest, it is possible to examine how ancient divination worked, and explore what this can tell us about what mattered to the individuals and cultures that used it,[16] without adopting uncritically the 'emic' perspective of our subjects, or simply describing the experiences of individual users of divination.[17]

## 3. Similarities and Differences

The essays in this volume cover a range of times and places: those on ancient Greek culture examine Archaic, Classical, and Hellenistic evidence; those on Roman cultures encompass the Republican to the Imperial periods. The editors elected not to extend into Late Antiquity, since it seems to us that divinatory rituals of that period begin to raise markedly different theological questions. We have, however, included here three essays that are intended to provide productive comparative insights. The coverage of cultures in the volume reflects the expertise of the conference participants. Comparative data from other ancient cultures (e.g. Jewish, Egyptian) would enrich the picture further, and we hope that this volume will inspire further work in all of these areas. Our goal here is not to provide comprehensive treatment of divination in all ancient cultures but to show how new approaches to divination can yield new insights in the study of many ancient peoples. The essays reflect on a broad range of divinatory practices, including not only oracles (Eidinow, Deeley, Maurizio, and Raphals), but also dreams

[16] The place of individual choice in everyday engagement in ancient religions has been emphasized by Jörg Rüpke's 'Lived Ancient Religion' project (University of Erfurt). Some of the participants in that project were also involved in Rosenberger 2014, which considered the role of the individual in ancient Greek divination. The essays in this volume build on this theme to offer some new examples of how divination influenced the lives of individuals (as well as groups and societies) in several ancient cultures.

[17] Emic perspectives: For discussion of the limitations of 'emic' approaches to religions, see e.g. Versnel 1991; McCutcheon 1999; Johnston 2003; McCutcheon 2007: ch. 6. On descriptive approaches, see n.4 above.

(Davies and Bowden), epiphanies (Flower), omens, prodigies and portents (Noegel, Santangelo, and Stiles), and sacrifice (Driediger-Murphy). This is a reminder of the variety of mechanisms available for individuals and communities to gain access to (what was perceived as divine) revelation, but it is not intended to be an implicit assertion that these practices are simply the same. Each study acknowledges the specifics of these different activities, in terms of not only the activities involved, but also the contexts in which they occurred and the implications they conveyed in and for those contexts. Indeed, acknowledging that these essays could have been organised in a number of different ways, we have arranged them so as to draw attention to some of these specifics and the resulting questions that they raise for modern scholarship. However, we hope our readers will find other themes across the essays that may suggest different commonalities.

Thus, the four essays in Part I: Expertise and Authority, examine the ways in which ancient societies attributed authority and claimed expertise, in the field of divination. Scott Noegel and Hugh Bowden both seek the diviners' perspectives, elucidating some of the difficulties of interpretation with which divinatory experts were thought to contend. Noegel's chapter takes us to the Near East, examining augury from the practitioner's own social, economic, and cosmological perspectives, and exploring how diviners negotiated two major sources of anxiety—scepticism from others and their own theological principles. Bowden brings us from the Near East to Classical Athens, and the case of Euxenippos, who was sent by the Athenians to consult the oracle of Amphiaraos at Oropos to help to resolve a land dispute—and was prosecuted for his interpretation of his divinatory dream. Bowden challenges the idea that Euxenippos was regarded simply as a private citizen and, with the aid of modern studies of dreams and dreaming, suggests instead that he may have been an 'expert dreamer', challenging categories commonly used in studies of Greek divination.

In turn, Eidinow and Davies focus on the ways in which, on the one hand, trust in authority, and on the other hand, locating (the right) expertise, were challenges for those who consulted divinatory experts. In part, the aim of Eidinow's chapter is to rehabilitate the Lydian king, Kroisos, so often accused of unGreek behaviour because of his so-called 'test of the oracles'. She does this by exploring the role of uncertainty in oracular consultations, and examining the ways in which the Greeks sought to resolve it through the practice of posing multiple questions (serially at one oracle, or simultaneously and successively at different oracles). Davies argues that what has long been seen as ancient debate about whether (all) dreams did or did not count as messages from the gods, can be better understood as an attempt by

each individual, in their specific context and circumstances, to determine *which* dreams were significant, by deploying widely shared strategies of interpretation. Returning to themes raised in, for example, Bowden's chapter, Davies draws attention to the ways in which dreams, while appearing 'to be a private event' were, in terms of their reception, interpretation and response, 'a public transaction, and how one responded to them was emphatically a social, religious and political act'.

These essays raise questions about the meanings attributed to signs, and the control of those interpretations, and this is the theme of the essays in Part II: Signs and Control. Maurizio interrogates the evidence for the argument that the Pythia at Delphi used sortition—and finds it wanting. She explores how anthropological studies suggest that divinatory pronouncements 'extend the reflection instigated by the consultation', a process which is unlikely to lead to a swift resolution of a problem—and which continues the consultant's process of reflection and interpretation, as well as their state of uncertainty. We move from Greece to Rome for the next three essays: first, Stiles explores how the Roman reception and interpretation of signs reported in the past (in this case, *omina imperii*, signs pertaining to the rule of individual emperors) could change over time in response to changing anxieties about the future and the gods' perceived plans for the Roman Empire. He places special emphasis on the often-overlooked role and experiences of non-elites as they created their own interpretations of signs pertaining to those in power. Second, Santangelo explores the fate of prodigy-interpretation under the Empire, challenging the long-held view that Roman emperors discouraged reports of unfavourable signs. He argues instead that the prodigy-system (and its attendant questions about the gods' intentions towards the state) remained a vital part of Rome's negotiation with the divine. Finally, Driediger-Murphy queries the current consensus that Roman divinatory sacrifices generally proceeded until a favourable sign was obtained (*usque ad litationem*). She argues that Roman magistrates took signs from failed sacrifices more seriously than we have often thought, and that this behaviour can be read as evidence that they were anxious about their relationship with their gods. These essays draw attention not only to the importance but also to the diversity of sign-interpretation in the ancient world, stressing the evidence in the ancient sources for the felt need to respond to perceived divine communications, and the anxieties these might provoke.

The essays in Part III build on this question of the nature of interactions with the divine, and focus on evidence for the perception of Divine

# Exploring the Variety of Random Documents with Different Content

heat, as in the case of rubber compositions, it is only reasonable to expect there will be some molecular rearrangement going on in the mass; and this can be assigned as the reason why some proofings last as long again as others. Some metallic salts have a very injurious action on rubber, one of the worst being copper sulphate. Dyers are frequently warned that goods for rubber-proofing must be free from this metal, as its action on rubber is very powerful, though but little understood. As is generally known, grease in any form is exceedingly destructive to rubber, and it should never be allowed in contact in the smallest proportion. Some compositions are made up by dissolving rubber in turpentine and coal tar; but in this case some of the rubber's most valuable properties are destroyed, and it is doubtful if it can be properly vulcanized. Owing to rubber being a bad conductor of heat, it requires considerable care to vulcanize it in any thickness. A high degree of heat applied during a short period would tend to form a layer of hard vulcanite on the surface, while that immediately below would be softer and would gradually merge into raw rubber in the center.

The different brands of rubber vary so much, especially with regard to solubility, that it is always advisable to treat each brand by itself, and not to make a solution of two or more kinds. Oilskins and tarpaulins, etc., are mostly proofed by boiled linseed oil, with or without thickening bodies added. They are not of sufficient interest to enlarge upon in this article, so the second, or "water-repellent," class has now to be dealt with.

All the shower-proof fabrics come under this heading, as well as every cloth which is pervious to air and repulsive to water. The most time-honored recipe for proofing woollen goods is a mixture of sugar of lead and alum, and dates back hundreds of years. The system of using this is as follows: The two ingredients are dissolved separately, and the solutions mixed together. A mutual decomposition results, the base of the lead salt uniting with the sulphuric acid out of the alum to form lead sulphate, which precipitates to the bottom. The

clear solution contains alumina in the form of acetate, and this supplies the proofing quality to the fabric. It is applied in a form of machine shown in Fig. 8, which will be seen to consist of a trough containing the proofing solution, *C*, with a pair of squeezing rollers, *A*, over the top. The fabric is drawn down through the solution and up through the squeezers in the direction of the arrows. At the {747} back of the machine the cloth automatically winds itself onto a roll, *B*, and then only requires drying to develop the water-resisting power. *D* is a weight acting on a lever which presses the two rollers, *A*, together. The water-repelling property is gained as follows:

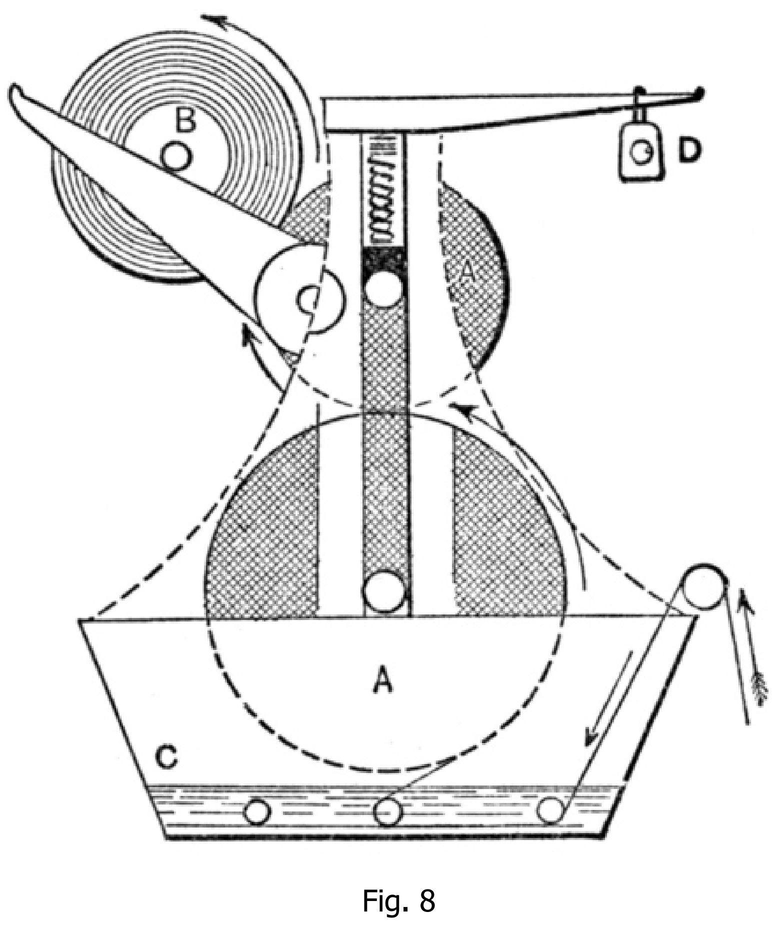


Fig. 8

Drying the fabric, which is impregnated with acetate of alumina, drives off some of the volatile acetic acid, leaving a film of basic acetate of alumina on each wool fiber. This basic salt is very difficult

to wet, and has so little attraction for moisture that in a shower of rain the drops remain in a spheroidal state, and fall off. In a strong wind, or under pressure, water eventually penetrates through fabrics proofed in this manner; but they will effectually resist a sharp shower. Unfortunately, shower-proofed goods, with wear, gradually lose this property of repelling water. The equation representing the change between alum and sugar of lead is given below. In the case of common alum there would, of course, be potassium acetate in solution besides the alumina.

$$\underset{\text{Alum.}}{Al_2K_2(SO_4)_4} + \underset{\text{Sugar of lead.}}{4\,Pb(C_2H_3O_2)_2} =$$

$$\underset{\text{Lead sulphate.}}{4\,PbSO_4} + \underset{\text{Potassium acetate.}}{2\,KC_2H_3O_2} + \underset{\text{Aluminum acetate.}}{Al_2(C_2H_3O_2)_6}$$

Now that sulphate of alumina is in common use, alum need not be used, as the potash in it serves no purpose in proofing.

There are many compositions conferring water resisting powers upon textiles, but unfortunately they either affect the general handle of the material and make it stiff, or they stain and discolor it, which is equally bad. A large range of waterproof compositions can be got by using stearates of the metals; these, in nearly every case, are insoluble bodies, and when deposited in the interior of a fabric form a water-resisting "filling" which is very effective. As a rule these stearates are deposited on the material by means of double baths; for example, by passing the fabric through (say) a bath of aluminum acetate, and then, after squeezing out the excess of liquid, passing it through a bath of soap. The aluminum salt on the fabric decomposes the soap, resulting in a deposit of insoluble stearate of alumina. This system of proofing in two baths is cleaner and more economical than adding all the ingredients together, as the stearate formed is just where it is required "on the fibers," and not at the bottom of the bath.

One of the most important patents now worked for waterproofing purposes is on the lines of the old alumina process. In this case the factor used is rosin, dissolved in a very large bulk of petroleum spirit. The fabrics to be proofed (usually dress materials) are passed through a bath of this solution, and carefully dried to drive off the solvent. Following this, the goods are treated by pressing with hot polished metal rollers. This last process melts the small quantity of rosin, which is deposited on the cloth, and leaves each single fiber with an exceedingly thin film of rosin on it. It will be understood that only a very attenuated solution of rosin is permissible, so that the fibers of the threads and not the threads themselves are coated with it. If the solution contains too much rosin the fabric is stiffened, and the threads cemented together; whereas if used at the correct strength (or, rather, weakness) neither fabric nor dye suffers, and there is no evidence of stickiness of any description.

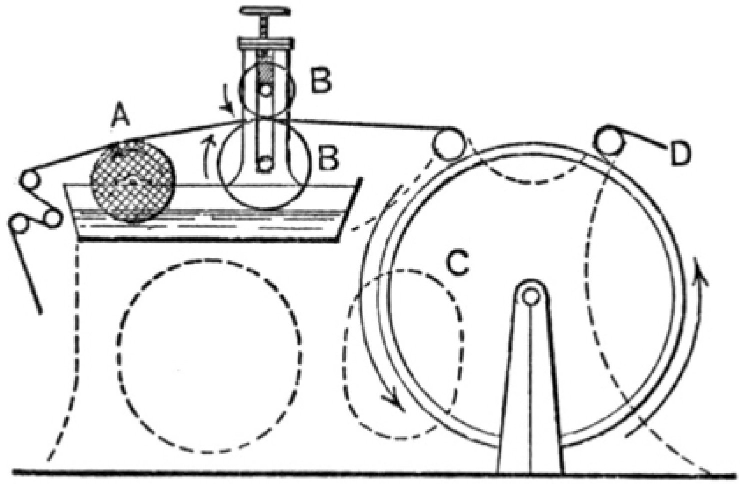


Fig. 9

Fig. 9 shows a machine used for spreading a coat of either proofing or any other fluid on one side of the fabric. {748} This is done by means of a roller, *A*, running in the proofing solution, the material to be coated traveling slowly over the top and just in contact with the roller, *A*, which transfers the proofing to it. Should the solution used be of a thick nature, then a smooth metal roller will transfer sufficient to the fabric. If the reverse is the case, and the liquid used is very thin, then the roller is covered with felt, which very materially adds to its carrying power. As shown in Fig. 9, after leaving the two squeezing rollers, *BB*, the fabric passes slowly round a large steam-heated cylinder, *C*, with the coated side uppermost. This dries the proofing and fastens it, and the cloth is taken off at *D*.

Besides stearates of the metals, glues and gelatins have been used for proofing purposes, but owing to their stiffening effect, they are only of use in some few isolated cases. With glue and gelatin the fixing agent is either tannic acid or some metallic salt. Tannic acid converts gelatin into an insoluble leather-like body; this can be deposited in the interstices of the fabric by passing the latter through a gelatin bath first, and then squeezing and passing through

the tannic acid. Bichromate of potash also possesses the property of fixing the proteid bodies and rendering them insoluble.

The following are special processes used to advantage in the manufacture of waterproof fabrics:

I.—Ordinary Fabrics, Dressing Apparel, etc.—Immerse in a vat of acetate of alumina (5° Bé.) for 12 hours, lift, dry, and let evaporate at a temperature of from 140° to 149° F.

II.—Sailcloth, Awnings, Thick Blankets, etc.—Soak in a 7 per cent solution of gelatin at 104° F., dry, pass through a 4 per cent solution of alum, dry again, rinse in water, and dry.

III.—Fabrics of Cotton, Linen, Jute, and Hemp.—Put into a bath of ammoniacal cupric sulphate of 10° Bé. at a temperature of 87° F.; let steep thoroughly, then put in a bath of caustic soda (20° Bé.) and dry. To increase the impermeability, a bath of sulphate of alumina may be substituted for the caustic-soda bath.

IV.—Saturate the fabrics with the following odorless compound, subjecting them several times to a brushing machine having several rollers, where the warp threads will be well smoothed, and a waterproof product of fine sheen and scarcely fading will be the result. The compound is made with 30 parts, by weight, of Japan wax, 22 $^1/_2$ parts, by weight, of paraffine, 12 parts, by weight, of rosin soap, 35 parts, by weight, of starch, and 5 parts, by weight, of a 5 per cent solution of alum. Fabrics thus prepared are particularly adapted to the manufacture of haversacks, shoes, etc.

V.—White or Light Fabrics.—Pass first through a bath of acetate of alumina of 4° to 5° Bé. at a temperature of 104° F., then through the rollers to rid of all liquid; put into a warm solution of soap (5 parts, by weight, of olive-oil soap to 100 parts, by weight, of fresh water) and finally pass through a 2 per cent solution of alum, dry for 2 or 3 days on the dropping horse, and brush off all particles of soap.

VI.—Dissolve 1 $^1/_2$ parts, by weight, of gelatin in 50 parts, by weight, of boiling water, add 1 $^1/_2$ parts, by weight, of scraped tallow

soap and 2 $^{1}/_{2}$ parts, by weight, of alum, the latter being put in gradually; lower the temperature of the bath to 122° F., lift out the fabric, dry, and calender.

VII.—Tent Cloth.—Soak in a warm solution of 1 part, by weight, of gelatin, 1 part, by weight, of glycerine, and 1 part, by weight, of tannin in 12 parts, by weight, of wood vinegar (pyroligneous acid) of 12° Bé. The whole is melted in a kettle and carefully mixed. The mass is poured into the receiver of the brushing machine, care being taken to keep it liquid. For a piece of 500 feet in length and 20 inches in width, 50 to 80 parts, by weight, of this compound are needed.

VIII.—To freshen worn waterproof material, cover with the following: Fifty-five thousand parts, by weight, of gelatin; 100 parts, by weight, of bichromate of potash; 100 parts, by weight, of acetic acid (to keep glue from congealing), and from 3,000 to 5,000 parts, by weight, of water; to this add 500 parts, by weight, of peroxide of ammoniacal copper, 100° Bé. This compound is put on the fabric with a brush and then exposed to air and light.

IX.—Soft Hats.—The hats are stiffened as usual, then put through the following three baths: Dissolve $^{1}/_{2}$ part, by weight, of tallow soap in from 40 to 50 parts, by weight, of warm water (140° F.). Put 3 to 4 dozen hats into this solution, leave them in it for half an hour, then take out and put them as they are into another bath prepared with 40 to 50 parts, by weight, of water and $^{1}/_{2}$ part, by weight, of alum and heated to 86° to 104° F. After  having been left in the second bath for $^{1}/_{4}$ or $^{1}/_{2}$ hour, take out as before, put into the third bath of 40 to 50 parts, by weight, of water, $^{1}/_{2}$ part, by weight, of alum, and about 13 parts, by weight, of fish glue. In this cold bath the hats are left for another $^{1}/_{2}$ hour or more until they are completely saturated with the liquid, then dried and the other operations continued.

X.—Woolen cloth may be soaked in a vat filled with aluminum acetate, of 5° Bé., for 12 hours, then removed, dried, and dried

again at a temperature of 140° F.

XI.—Wagon covers, awnings, and sails are saturated with a 7 per cent gelatin solution, at a temperature of 104° F., dried in the air, put through a 4 per cent solution of alum, dried again in the air, carried through water, and dried a third time.

XII.—Cotton, linen, jute, and hemp fabrics are first thoroughly saturated in a bath of ammonio-cupric sulphate, of 10° Bé., at a temperature of 77° F., then put into a solution of caustic soda, 2° Bé., and dried. They may be made still more impervious to water by substituting a solution of aluminum sulphate for the caustic soda.

XIII.—White and light-colored fabrics are first put into a bath of aluminum acetate, 4° to 5° Bé., at a temperature of 102° F., the superfluous liquid being removed from the fabric by press rollers. The fabric is put into a soap solution (5 parts of good Marseilles soap in 100 parts of soft water). Finally it is put through a 2 per cent alum solution, and left to dry for 2 or 3 days on racks. The adhering particles of soap are removed by brushing with machinery.

XIV.—Dissolve 1.5 parts of gelatin in 50 parts of boiling water, add 1.5 parts of shavings of tallow grain soap, and gradually, 2.5 parts of alum. Let this cool to 122° F., draw the fabric through it, dry and calender.

XV.—Cellular tissues are made waterproof by impregnating them with a warm solution of 1 part, by weight, of gelatin, 1 part, by weight, of glycerine, and 1 part, by weight, of tannin, in 12 parts, by weight, of wood vinegar, 12° Bé.

XVI.—Linen, hemp, jute, cotton, and other fabrics can be given a good odorless waterproof finish by impregnating them, and afterwards subjecting them to the action of several mechanical brush rollers. By this process the fabric is brushed dry, the fibers are laid smooth, the threads of the warp brought out, and a glossy, odorless, unfading waterproof stuff results. Fabrics manufactured in the usual way from rough and colored yarns are put through a bath of this waterproof finish, whose composition is as follows: Thirty parts, by

weight, of Japanese wax; 22.5 parts, by weight, of paraffine; 15 parts, by weight, of rosin soap; 35 parts, by weight, of starch, and 5 parts, by weight, of a 5 per cent alum solution. The first three components are melted in a kettle, the starch and, lastly, the alum added, and the whole stirred vigorously.

XVII.—One hundred parts, by weight, of castor oil are heated to nearly 204° F., with 50 parts, by weight, of caustic potash, of 50° Bé., to which 50 parts, by weight, of water have previously been added. Forty parts, by weight, of cooler water are then added slowly, care being taken to keep the temperature of the mixture constant. As soon as the liquor begins to rise, 40 parts, by weight, of cooler water are again added, with the same precaution to keep the temperature from falling below 204° F. At the same time care must be taken to prevent the liquor boiling, as this would produce too great saponification. By the prolonged action of heat below the boiling point, the oil absorbs water and caustic potash without being changed, and the whole finally forms a perfectly limpid, nearly black liquid. This is diluted with 5 times its weight of hot or cold water, and is then ready for use without any further preparation. Other vegetable oils may be employed besides castor oil, and the quantity of unsaponified oil present may be increased by stirring the prepared liquid with a fresh quantity of castor or other vegetable oil. The product is slightly alkaline, but wool fiber is not injured, as the oiling may be done in the cold. The solution is clear and limpid, and will not separate out on standing like an emulsion. This product in spinning gives a 10 per cent better utilization of the raw material owing to the greater evenness and regularity with which the fibers are oiled; in weaving less oiling is required.

The product can be completely removed by water, preferably by cold water, and scouring of the goods subsequently with soap, soda, or fuller's earth can thus be dispensed with.

XVIII.—Cloth may be rendered waterproof by rubbing the under side with a lump of beeswax until the surface presents a uniform

white or grayish appearance. This method it is said renders the cloth {750} practically waterproof, although still leaving it porous to air.

XIX.—Coating the under side of the cloth with a solution of isinglass and then applying an infusion of galls is another method, a compound being thus formed which is a variety of leather.

XX.—An easy method is the formation of aluminum stearate in the fiber of the cloth, which may readily be done by immersing it in a solution of aluminum sulphate in water (1 in 10) and without allowing it to dry passing through a solution of soap made from soda and tallow or similar fat, in hot water. Reaction between the aluminum sulphate and the soap produces aluminum stearate and sodium sulphate. The former is insoluble and remains in the fiber; the latter is removed by subsequently rinsing the fabric in water.

XXI.—A favorite method for cloth is as follows: Dissolve in a receptacle, preferably of copper, over a bright coal fire, 1 liter (1.76 pints) of pure linseed oil, 1 liter (1.76 pints) of petroleum, $^1/_2$ liter (0.88 pints) of oil turpentine, and 125 grams (4.37 ounces) of yellow wax, the last named in small bits. As there is danger of fire, boiling of this mass should be avoided. With this hot solution removed from the fire, of course the felt material is impregnated; next it is hung up in a warm, dry room or spread out, but in such a manner that the uniform temperature can act upon all parts.

**Waterproofing Leather.**—I.—Tenning’s process is as follows: Melt together equal parts of zinc and linseed oil, at a temperature not above 225° F. Put the leather in the molten mixture and let it remain until saturated. The “zinc soap” is made by dissolving 6 parts of white soap in 16 parts of water, and stirring into the solution 6 parts of zinc sulphate. To make sure of a homogeneous mixture remelt the whole and stir until it begins to cool. The process, including the saturation of the leather, requires about 48 hours. Instead of zinc sulphate, copper or iron sulphate may be used. The philosophy of the process is that the moisture and air contained in the pores of the

leather are driven out by the heat of the soap mixture, and their place is taken, on cooling, by the mixture. The surface of the leather is scraped after cooling, and the article is dried, either by heating over an open fire or by hanging in a drying room, strongly heated.

II.—Prideaux' process consists in submitting the leather to treatment with a solution of caoutchouc until it is thoroughly saturated with the liquid. The latter consists of 30 parts of caoutchouc in 500 parts of oil of turpentine. Complete impregnation of the leather requires several days, during which the solution must be frequently applied to the surface of the leather and rubbed in.

III.—Villon's process consists in applying a soap solution to the leather, about as follows: The leather is first treated to a solution of 62 parts of soap, 124 parts of glue, and 2,000 parts of water. When it has become saturated with the solution, it is treated to rubbing with a mixture of 460 parts of common salt and 400 parts of alum, in sufficient water to dissolve the same. After this it is washed with tepid water and dried. This process is much the quickest. The application of the soap requires about 2 hours, and the subsequent treatment about as much more, or 4 or 5 hours in all.

**Oilskins.**—The art of painting over textile fabrics with oily preparations to make them waterproof is probably nearly as old as textile manufacture itself, an industry of prehistoric, nay, geologic, origin. It is certainly more ancient than the craft of the artistic painter in oils, whose canvases are nothing more nor less than art oilskins, and when out of their frames, have served the usual purpose of those things in protecting goods or the human body before now. The art of waterproofing has been extended beyond the domain of the oilskin by chemical processes, especially those in which alum or lead salts, or tannin, are used, as well as by the discovery of India rubber and gutta percha. These two have revolutionized the waterproofing industry in quite a special manner, and the oilskin manufacture, although it still exists and is in a fairly

flourishing condition, has found its products to a very large extent replaced by rubber goods. The natural result has been that the processes used in the former industry have remained now unchanged for a good many years. They had already been brought to a very perfect state when the rubber-waterproofing business sprang up, so that improvements were even then difficult to hit upon in oilskin making, and the check put upon the trade by India rubber made people less willing to spend time and money in experimenting with a view to improving what many years had already made it difficult to better. Hence the three cardinal defects of the oilskin: its weight, its stiffness, and the liability of {751} its folds to stick together when it is wrapped up, or in the other extreme to crack, still remains. The weight, of course, is inevitable. An oilskin must be heavy, comparatively, from the very essence of the process by which it is made, but there seems no reason why it should not in time be made much more pliable (an old-time oilskin coat could often stand up on end when empty) and free from the danger of cracking or being compacted into a solid block when it has been stored folded on a shelf.

Probably the best oilskins ever made are those prepared by combining Dr. Stenhouse's process (patented in 1864) with the ordinary method, which consists in the main of painting over the fabric with two or more coats of boiled linseed oil, allowing each coat to dry before the next is applied. This, with a few variations in detail, is the whole method of making oilskins. Dr. Stenhouse's waterproofing method is to impregnate the fabric with a mixture of hard paraffine and boiled oil in proportions varying according to circumstances from 95 per cent of paraffine and 5 of oil to 70 per cent of the former and 30 of the latter. The most usual percentages are 80 and 20. The mixture is made with the aid of heat, and is then cast into blocks for storage. It is applied to the cloth stretched on a hot plate by rubbing the fabric thoroughly all over with a block of the composition, which may be applied on one or both sides as may be

wished. The saturation is then made complete, and excess of composition is removed by passing the cloth between hot rollers. When the cloth is quite cold the process is complete. The paraffine and the drying oil combine their waterproofing powers, and the paraffine prevents the oil from exerting any injurious action upon the material. Drying oil, partly on account of the metallic compounds in it, and partly on account of its absorbing oxygen from the atmosphere, has a decided slow weakening effect upon textile fibers. Dr. Stenhouse points out that the inflammability of oilskins may be much lessened by the use of the ordinary fireproofing salts, such as tungstate of soda, or alum, either before or after the waterproofing process is carried out.

The following are some of the best recommended recipes for making oilskins:

I.—Dissolve 1 ounce of yellow soap in 1 $^1/_2$ pints of boiling water. Then stir in 1 quart of boiled oil. When cold, add $^1/_4$ pint of gold size.

II.—Take fine twilled calico. Soak it in bullock's blood and dry it. Then give it 2 or 3 coats of boiled oil, mixed with a little litharge, or with an ounce of gold size to every pint of the oil.

III.—Make ordinary paint ready to be applied thin with a strong solution of soap.

IV.—Make 96 pounds of ocher to a thin paste with boiled oil, and then add 16 pounds of ordinary black paint mixed ready for use. Apply the first coat of this with soap, the subsequent coats without soap.

V.—Dissolve rosin in hot boiled oil till it begins to thicken.

VI.—Mix chalk or pipe clay in the finest powder, and in the purest state obtainable to a thin paste with boiled oil.

VII.—Melt together boiled oil, 1 pint; beeswax and rosin, each, 2 ounces.

VIII.—Dissolve soft soap in hot water and add solution of protosulphate of iron till no further precipitate is produced. Filter off,

wash, and dry, and form the mass into a thin paste with boiled oil.

All these compositions are painted on with an ordinary painter's brush. The fabric should be slightly stretched, both to avoid folds and to facilitate the penetration of the waterproofing mixture. To aid the penetration still further, the mixture should be applied hot. It is of the greatest importance that the fabric should not be damp when the composition is applied to it. It is best to have it warm as well as the composition. If more than one coat is applied, which is practically always the case, three being the usual number, it is essential that the last coat should be perfectly dry before the next is applied. Neglect of this precaution is the chief cause of stickiness, which frequently results in serious damage to the oilskins when they have to be unfolded. In fact, it is advisable to avoid folding an oilskin when it can be avoided. They should be hung up when not in use, whenever practicable, and be allowed plenty of room. It goes without saying that no attempt should be made to sell or use the oilskin, whether garment or tarpaulin, until the final coat of composition is perfectly dry and set. It is unadvisable to use artificial heat in the drying at any stage in the manufacture.

**Waterproofing Paper.**—Any convenient and appropriate machinery or apparatus may be employed; but the best method for waterproofing paper is as follows: The treatment may be applied {752} while the pulp is being formed into paper, or the finished paper may be treated. If the material is to be treated while being formed into paper, then the better method is to begin the treatment when the web of pulpy material leaves the Foudrinier wire or the cylinders, it then being in a damp condition, but with the larger percentage of moisture removed. From this point the treatment of the paper is the same whether it be pulp in a sheet, as above stated, or finished paper.

The treatment consists, first, in saturating the paper with glutinous material, preferably animal glue, and by preference the

bath of glutinous material should be hot, to effect the more rapid absorption and more perfect permeation, impregnation, and deposit of the glutinous material within all the microscopic interstices throughout the body of the paper being treated. By preference a suitable tank is provided in which the glutinous material is deposited, and in which it may be kept heated to a constant temperature, the paper being passed through the tank and saturated during its passage. The material being treated should pass in a continuous sheet—that is, be fed from a roll and the finished product be wound in a roll after final treatment. This saves time and the patentee finds that the requisite permeation or incorporation of glutinous matter in the fiber will with some papers—for instance, lightly sized manila hemp—require but a few seconds. As the paper passes from the glutin tank the surplus of the glutinous matter is removed from the surface by mechanical means, as contradistinguished from simply allowing it to pass off by gravity, and in most instances it is preferred to pass the paper between suitable pressure rolls to remove such surplus. The strength and consistency of the glutinous bath may be varied, depending upon the material being treated and the uses for which such material is designed. It may, however, be stated that, in a majority of cases, a hot solution of about 1 part of animal glue to about 10 parts of water, by weight, gives the best results. After leaving the bath of glutinous material and having the surplus adhering to the surfaces removed, the paper before drying is passed into or through a solution of formaldehyde and water to "set" the glutinous material. The strength of this solution may also be variable, depending, as heretofore stated, upon the paper and uses for which it is designed. In the majority of cases, however, a solution of 1 part of formaldehyde (35 per cent solution) to 5 parts of water, by weight, gives good results, and the best result is attained if this bath is cold instead of hot, though any particular temperature is not essentially necessary. The effect of the formaldehyde solution upon

the glutin-saturated paper is to precipitate the glutinous matter and render it insoluble.

As the material comes from the formaldehyde bath, the surplus adhering to the surfaces is removed by mechanical means, pressure rolls being probably most convenient. The paper is then dried in any convenient manner. The best result in drying is attained by the air-blast, i. e., projecting blasts of air against both surfaces of the paper. This drying removes all the watery constituents and leaves the paper in a toughened or greatly strengthened condition, but not in practical condition for commercial uses, as it is brittle, horny, and stiff, and has an objectionable odor and taste on account of the presence of the aldehydes, paraldehydes, formic acid, and other products, the result of oxidation. Hence it needs to be "tempered." Now while the glutinous material is rendered insoluble—that is, it is so acted upon by formaldehyde and the chemical action which takes place while the united solutions are giving off their watery constituents that it will not fully dissolve—it is, however, in a condition to be acted on by moisture, as it will swell and absorb, or take up permanently by either chemical or mechanical action a percentage of water, and will also become improved in many respects, so that to temper and render the paper soft and pliable and adapt it for most commercial uses it is subjected to moisture, which penetrates the paper, causing a welling in all directions, filling the interstices perfectly and resulting in "hydration" throughout the entire cellular structure. Two actions, mechanical and chemical, appear to take place, the mechanical action being the temporary absorption of water analogous to the absorption of water by a dry sponge, the chemical action being the permanent union of water with the treated paper, analogous to the union of water and tapioca, causing swelling, or like the chemical combination of water with lime or cement. For this purpose it is preferred to pass the paper into a bath of hot water, saturated steam or equivalent heat-and-moisture medium, thus causing the fibers and the non-soluble glutinous material filling the interstices to

expand in all directions and forcing {753} the glutinous material into all the microscopic pores or openings and into the masses of fiber, causing a commingling or thorough incorporation of the fibers and the glutinous compound. At the same time, as heretofore indicated, a change (hydration) takes place, whereby the hardened mass of fiber, glutinous material, and formaldehyde become tempered and softened and the strength imparted by the previous treatment increased. To heighten the tempering and softening effect, glycerine may, in some instances, be introduced in the tempering bath, and in most cases one two-hundredths in volume of glycerine gives the best results.

The paper may be dried in any convenient manner and is in condition for most commercial uses, it being greatly strengthened, more flexible, more impervious to moisture, acids, grease, or alkalies, and is suitable for the manufacture of binding-twine, carpets, and many novelties, for dry wrappings and lining packing cases, etc., but is liable to have a disagreeable taste and may carry traces of acids, rendering it impracticable for some uses—for instance, wrapping butter, meats, cheese, etc., after receiving the alkali treatment. The paper is also valuable as a packing for joints in steam, water, and other pipes or connections. For the purpose, therefore, of rendering the material absolutely free from all traces of acidity and all taste and odors and, in fact, to render it absolutely hygienic, it is passed through a bath of water and a volatile alkali (ammonium hydrate), the proportion by preference in a majority of cases being one-hundredth of ammonium hydrate to ninety-nine one-hundredths of water by volume. A small percentage of wood alcohol may be added. This bath is preferably cool, but a variation in its temperature will not interfere to a serious extent with the results. The effect of this bath followed by drying is to complete the chemical reaction and destroy all taste or odor, removing all traces of acids and rendering the paper hygienic in all respects. The material may be calendered or cut and used for any of the purposes desired.

If the material is to be subjected to the volatile alkali bath, it is not necessary to dry it between the tempering and volatile alkali baths.

The paper made in accordance with the foregoing will, it is claimed, be found to be greatly strengthened, some materials being increased in strength from 100 to 700 per cent. It will be nonabsorbent to acids, greases, and alkalies, and substantially waterproof, and owing to its component integrate structure will be practically non-conductive to electricity, adapting it as a superior insulating material. It may with perfect safety be employed for wrapping butter, meats, spices, groceries, and all materials, whether unctuous or otherwise.

The term “hydration” means the subjecting of the material (after treatment with glutinous material and formaldehyde and drying) to moisture, whereby the action described takes place.

A sheet or web of paper can be treated by the process as rapidly as it is manufactured, as the time for exposure to the action of the glutinous material need not be longer than the time required for it to become saturated, this, of course, varying with different thicknesses and densities, and the length of time of exposure may be fixed without checking the speed by making the tank of such length that the requisite time will elapse while the sheet is passing through it and the guides so arranged as to maintain the sheet in position to be acted on by such solution the requisite length of time. Four seconds’ exposure to the action of formaldehyde is found sufficient in most cases.

**Waterproof Ropes.**—For making ropes and lines impervious to weather, the process of tarring is recommended, which can be done either in the separate strands or after the rope is twisted. An addition of tallow gives greater pliability.

**Waterproof Wood.**—I.—Soak in a mixture of boracic acid, 6 parts; ammonium chloride, 5 parts; sodium borate, 3 parts, and water, 100 parts.

II.—Saturate in a solution of zinc chloride.

## WAX

**Adulteration Of Wax.**—Wax is adulterated with the following among other substances: Rosins, pitch, flowers of sulphur, starch, fecula, stearine, paraffine, tallow, palm oil, calcined bones, yellow ocher, water, and wood sawdust.

Rosins are detected by cold alcohol, which dissolves all rosinous substances and exercises no action on the wax. The rosins having been extracted from the alcoholic solution by the evaporation of the alcohol, the various kinds may be distinguished by the odors disengaged by burning the mass several times on a plate of heated iron.

All earthy substances may be readily {754} separated from wax by means of oil of turpentine, which dissolves the wax, while the earthy matters form a residue.

Oil of turpentine also completely separates wax from starchy substances, which, like earthy matters, do not dissolve, but form a residue. A simpler method consists in heating the wax with boiling water; the gelatinous consistency assumed by the water, and the blue coloration in presence of iodine, indicate that the wax contains starchy substances. Adulteration by means of starch and fecula is quite frequent. These substances are sometimes added to the wax in a proportion of nearly 60 per cent. To separate either, the suspected product is treated hot with very dilute sulphuric acid (2 parts of acid per 100 parts of water). All amylaceous substances, converted into dextrin, remain dissolved in the liquid, while the wax, in cooling, forms a crust on the surface. It is taken off and weighed; the difference between its weight and that of the product analyzed will give the quantity of the amylaceous substances.

Flowers of sulphur are recognized readily from the odor of sulphurous acid during combustion on red-hot iron.

Tallow may be detected by the taste and odor. Pure wax has an aromatic, agreeable taste, while that mixed with tallow is repulsive both in taste and smell. Pure wax, worked between the fingers, grows soft, preserving a certain cohesion in all parts. It divides into lumps, which adhere to the fingers, if it is mixed with tallow. The adulteration may also be detected by the thick and nauseating fumes produced when it is burned on heated iron.

Stearic acid may be recognized by means of boiling alcohol, which dissolves it in nearly all proportions and causes it to deposit crystals on cooling, while it is without action on the wax. Blue litmus paper, immersed in alcohol solution, reddens on drying in air, and thus serves for detecting the presence of stearic acid.

Ocher is found by treating the wax with boiling water. A lemon-yellow deposit results, which, taken up with chlorhydric acid, yields with ammonia a lemon-yellow precipitate of ferric oxide.

The powder of burnt bones separates and forms a residue, when the wax is heated with oil of turpentine.

**Artificial Beeswax.**—This is obtained by mixing the following substances, in approximately the proportions stated: Paraffine, 45 parts, by weight; white Japan vegetable wax, 30 parts, by weight; rosins, or colophonies, 10 parts, by weight; white pitch, 10 parts, by weight; tallow, 5 parts, by weight; ceresine, colorant, 0.030 parts, by weight; wax perfume, 0.100 parts, by weight. If desired, the paraffine may be replaced with ozokerite, or by a mixture of vaseline and ozokerite, for the purpose of varying the fusing temperature, or rendering it more advantageous for the various applications designed. The following is the method of preparation: Melt on the boiling water bath, shaking constantly, the paraffine, the Japan wax, the rosins, the pitch, and the tallow. When the fusion is complete, add the colorant and the perfume. When these products are

perfectly mingled, remove from the fire, allow the mixture to cool, and run it into suitable molds. The wax thus obtained may be employed specially for encaustics for furniture and floors, or for purposes where varnish is employed.

**Waxes For Floors, Furniture, Etc.—**

| | | |
|---|---|---|
| I.— | White beeswax | 16 parts |
| | Colophony | 4 parts |
| | Venice turpentine | 1 part |

Melt the articles together over a gentle fire, and when completely melted and homogeneous, pour into a sizable earthenware vessel, and stir in, while still warm, 6 parts of the best French turpentine. Cool for 24 hours, by which time the mass has acquired the consistence of soft butter, and is ready for use. Its method of use is very simple. It is smeared, in small quantities, on woolen cloths, and with these is rubbed into the wood.

This is the best preparation, but one in which the beeswax is merely dissolved in the turpentine in such a way as to have the consistence of a not too thin oil color, will answer. The wood is treated with this, taking care that the surface is evenly covered with the mixture, and that it does not sink too deeply in the ornaments, corners, etc., of the woodwork. This is best achieved by taking care to scrape off from the cloths all excess of the wax.

If, in the course of 24 hours, the surface is hard, then with a stiff brush go over it, much after the way of polishing a boot. For the corners and angles smaller brushes are used; when necessary, stiff pencils may be employed. Finally, the whole is polished with plush, or velvet rags, in order not to injure the original polish. Give the article a good coat of linseed oil or a washing with petroleum before beginning work.

II.—Articles that are always exposed to the water, floors, doors, especially of oak, should, from time to time, be {755} saturated with oil or wax. A house door, plentifully decorated with wood carving,

will not shrink or warp, even where the sun shines hottest on it, when it is frequently treated to saturation with wax and oil. Here a plain dosage with linseed oil is sufficient. Varnish, without the addition of turpentine, should never be used, or if used it should be followed by a coat of wax.

III.—A good floor wax is composed of 2 parts of wax and 3 parts of Venice turpentine, melted on the water bath, and the mixture applied while still hot, using a pencil, or brush, for the application, and when it has become solid and dry, diligently rubbed, or polished down with a woolen cloth, or with a floor brush, especially made for the purpose.

IV.—An emulsion of 5 parts of yellow wax, 2 parts of crude potassium carbonate, and 12 parts of water, boiled together until they assume a milky color and the solids are dissolved, used cold, makes an excellent composition for floors. Any desired color may be given this dressing by stirring in the powdered coloring matter. Use it exactly as described for the first mass.

**Gilders' Wax.**—For the production of various colorings of gold in fire gilding, the respective places are frequently covered with so-called gilders' wax. These consist of mixtures of various chemicals which have an etching action in the red heat upon the bronze mass, thus causing roughness of unequal depth, as well as through the fact that the composition of the bronze is changed somewhat on the surface, a relief of the gold color being effected in consequence of these two circumstances. The gilding wax is prepared by melting together the finely powdered chemicals with wax according to the following recipes:

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| Yellow wax | 32 | 32 | 32 | 96 | 36 |
| Red chalk | 3 | 24 | 18 | 48 | 18 |
| Verdigris | 2 | 4 | 18 | 32 | 18 |
| Burnt alum | 2 | 4 | — | — | — |
| Burnt borax | — | — | 2 | 1 | 3 |
| Copper ash | — | 4 | 6 | 20 | 8 |
| Zinc vitriol | — | — | — | 32 | 18 |
| Green vitriol | — | — | — | 1 | 6 |

**Grafting Wax.—**

| | | |
|---|---|---|
| I.— | Beeswax | 7 parts |
| | Purified rosin | 12 parts |
| | Turpentine | 3 parts |
| | Rape oil | 1 part |
| | Venice turpentine | 2.5 parts |
| | Zinc white | 2.5 parts |

Color yellow with turmeric.

| | | |
|---|---|---|
| II.— | Japan wax | 1 part |
| | Yellow wax | 3 parts |
| | Rosin | 8 parts |
| | Turpentine | 4 parts |
| | Hard paraffine | 1 part |
| | Suet | 3 parts |
| | Venice turpentine | 6 parts |

**Harness Wax.—**

| | |
|---|---|
| Oil of turpentine | 90 parts |
| Wax, yellow | 9 parts |
| Prussian blue | 1 part |
| Indigo | 0.5 parts |
| Bone black | 5 parts |

Dissolve the wax in the oil by aid of a low heat, on a water bath. Mix the remaining ingredients, which must be well powdered, and work up with a portion of the solution of wax. Finally, add the mixture to the solution, and mix thoroughly on the bath. When a homogeneous liquid is obtained, pour into earthen boxes.

**Modeling Wax.**—I.—Yellow wax, 1,000 parts; Venice turpentine, 130 parts; lard, 65 parts; bole, 725 parts. The mixture when still liquid is poured into tepid water and kneaded until a plastic mass is obtained.

II.—Summer Modeling Wax.—White wax, 20 parts; ordinary turpentine, 4 parts; sesame oil, 1 part; vermilion, 2 parts.

III.—Winter Modeling Wax.—White wax, 20 parts; ordinary turpentine, 6 parts; sesame oil, 2 parts; vermilion, 2 parts. Preparation same as for Formula I.

**Sealing Waxes.**—The following formulas may be followed for making sealing wax: Take 4 pounds of shellac, 1 pound of Venice turpentine, and 3 pounds of vermilion. Melt the lac in a copper pan suspended over a clear charcoal fire, then add the turpentine slowly to it, and soon afterwards add the vermilion, stirring briskly all the time with a rod in either hand. In forming the round sticks of sealing wax, a certain portion of the mass should be weighed while it is ductile, divided into the desired number of pieces, and then rolled out upon a warm marble slab by means of a smooth wooden block like that used by apothecaries for rolling a mass of pills.

The oval and square sticks of sealing wax are cast in molds, with the above compound, in a state of fusion. The marks of the lines of junction of the mold box may be afterwards removed by holding the sticks over a clear fire, or passing them over a blue gas flame. Marbled sealing wax is made by mixing {756} two, three, or more colored kinds together while they are in a semi-fluid state. From the viscidity of the several portions their incorporation is left incomplete, so as to produce the appearance of marbling. Gold sealing wax is

made simply by adding gold chrome instead of vermilion into the melted rosins. Wax may be scented by introducing a little essential oil, essence of musk, or other perfume. If 1 part of balsam of Peru be melted along with 99 parts of the sealing-wax composition, an agreeable fragrance will be exhaled in the act of sealing with it. Either lampblack or ivory black serves for the coloring matter of black wax. Sealing wax is often adulterated with rosin, in which case it runs into thin drops at the flame of a candle.

The following mistakes are sometimes made in the manufacture of sealing wax:

I.—Use of filling agents which are too coarsely ground.

II.—Excessive use of filling agents.

III.—Insufficient binding of the pigments and fillings with a suitable adhesive agent, which causes these bodies to absorb the adhesive power of the gums.

IV.—Excessive heating of the mass, caused by improper melting or faulty admixture of the gummy bodies. Turpentine and rosin must be heated before entering the shellac. If this rule is inverted, as is often the case, the shellac sticks to the bottom and burns partly.

Great care must be taken to mix the coloring matter to a paste with spirit or oil of turpentine before adding to the other ingredients. Unless this is done the wax will not be of a regular tint.

**Dark Blue Wax.**—Three ounces Venetian turpentine, 4 ounces shellac, 1 ounce rosin, 1 ounce Prussian blue, $^1/_2$ ounce magnesia.

**Green Wax.**—Two ounces Venetian turpentine, 4 ounces shellac, 1 $^1/_4$ ounces rosin, $^1/_2$ ounce chrome yellow, $^1/_4$ ounce Prussian blue, 1 ounce magnesia.

**Carmine Red Wax.**—One ounce Venetian turpentine, 4 ounces shellac, 1 ounce rosin, colophony, 1 $^1/_4$ ounces Chinese red, 1 drachm magnesia, with oil of turpentine.

**Gold Wax.**—Four ounces Venetian turpentine, 8 ounces shellac, 14 sheets of genuine leaf gold, $^1/_2$ ounce bronze, $^1/_2$ ounce magnesia, with oil of turpentine.

**White Wax.**—I.—The wax is bleached by exposing to moist air and to the sun, but it must first be prepared in thin sheets or ribbons or in grains. For this purpose it is first washed, to free it from the honey which may adhere, melted, and poured into a tin vessel, whose bottom is perforated with narrow slits. The melted wax falls in a thin stream on a wooden cylinder arranged below and half immersed in cold water. This cylinder is turned, and the wax, rolling round in thin leaves, afterwards falls into the water. To melt it in grains, a vessel is made use of, perforated with small openings, which can be rotated. The wax is projected in grains into the cold water. It is spread on frames of muslin, moistened with water several times a day, and exposed to the sun until the wax assumes a fine white. This whiteness, however, is not perfect. The operation of melting and separating into ribbons or grains must be renewed. Finally, it is melted and flowed into molds. The duration of the bleaching may be abridged by adding to the wax, treated as above, from 1.25 to 1.75 per cent of rectified oil of turpentine, free from rosin. In 6 or 8 days a result will be secured which would otherwise require 5 or 6 weeks.

| | | |
|---|---|---|
| II.— | Bleached shellac | 28 parts |
| | Venetian turpentine | 13 parts |
| | Plaster of Paris | 30 parts |

WAX FOR BOTTLES: See Photography.

WAX, BURNING, TRICK: See Pyrotechnics.

WAXES, DECOMPOSITION OF: See Oil.

WAX FOR IRONING: See Laundry Preparations.

WAX FOR LINOLEUM: See Linoleum.

## WEATHER FORECASTERS